



The Coalescence of the Foramen Lacerum

Foramen Lacerum Kaynaması

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Özet

Foramen lacerum, oksipital, sfenoid ve temporal kemiklerin arasında kraniyumun tabanında yerleşik foramendir. İntrakranial anevrizmaların varlığının tespiti amacıyla bilgisayarlı tomografik anjiyografileri değerlendirilen hastalar çalışmaya dahil edildi. Elde edilen veriler DICOM formatında kaydedilip görüntü analiz yazılımları kullanılarak üç boyutlu nörovasküler görüntü formatına dönüştürüldü. Elde edilen görüntülerde 6 hastada (3 erkek, 3 bayan)foramen lacerum'da kaynama tespit edildi. Erkek hastalarda anteriordan posteriora doğru kaynama boyutları sağ tarafta $0,41 \pm 0,045$ (Ortalama±Standart ortalama hata) cm, sol tarafta ise $0,2 \pm 0,03$ cm bulundu. Bayan hastalarda bu değerler sağ tarafta $0,36 \pm 0,04$ cm ve sol tarafta $0,37 \pm 0,04$ cm olarak bulundu. Diğer taraftan erkek hastalarda medial-lateral boyutlar sağ tarafta $0,2 \pm 0,03$ cm ve sol tarafta $0,23 \pm 0,12$ cm bulundu. Aynı değerler bayan hastalarda sağ tarafta $0,14 \pm 0,009$ cm ve sol tarafta $0,13 \pm 0,016$ cm olarak bulundu. Bir hastada unilateral kaynama gözlenirken diğer beş hastada bilateral kaynama tespit edildi. Bu çalışmada foramen lacerum kaynaması, şekli ve boyutlarıyla tanımlanmıştır.

Anahtar Kelimeler

Foramen Lacerum Kaynaması; Internal Carotid Arter; Hacim Betimleme Tekniği; Üç Boyutlu Resimler

Abstract

The foramen lacerum is a bony foramen located in the base of the cranium between the occipital, sphenoid, and temporal bones. To evaluate the presence or absence of intracranial aneurysms, the patients included in this study were evaluated with computerized tomographic angiography. Imaging data were stored in digital imaging and communications in medicine (DICOM) format and subsequently converted by imaging software into three-dimensional volume rendered neurovascular images. These images of the 6 patients in the study (3 male and 3 female) showed the coalescence of the foramen lacerum. In the three males, the average dimension of the coalescent foramen lacerum in the anterior-to-posterior direction was estimated as 0.41 ± 0.045 (Mean±SEM) centimeters on the right side and 0.2 ± 0.03 centimeters on the left side. In the three females, the average values were estimated as 0.36 ± 0.04 centimeters on the right side and 0.37 ± 0.04 centimeters on the left side. In the males, the average medial-lateral dimensions were estimated as 0.2 ± 0.03 centimeters on the right side and 0.23 ± 0.12 centimeters on the left side. In the females, the average medial-lateral dimensions were estimated as 0.14 ± 0.009 centimeters on the right side and 0.13 ± 0.016 centimeters on the left side. One case had unilateral coalescent foramen lacerum. The other five cases had bilateral coalescent foramen lacerum. The present study defines the term coalescent foramen lacerum and describes its shape and dimensions.

Keywords

Coalescence Of Foramen Lacerum; Internal Carotid Artery; Volume Rendering Technique; Three-Dimensional Images

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Introduction

The foramen lacerum is a bony foramen between the sphenoidal, occipital, and temporal bones located in the cranial base. The term lacerum has a Latin origin meaning a lacerated piercing. No important neural or vascular structures pass through it. The foramen lacerum is a bilateral opening between the crossing points of the fundamental bones of the cranial base. The artery and nerve of the pterygoid canal and some venous structures pass through the foramen lacerum. The relationship to the internal carotid artery and carotid canal is an important anatomical detail in the base of the cranium. The foramen lacerum is located just inferior to the internal opening of the carotid canal. It is important to note that the internal carotid artery does not travel through the foramen lacerum. Instead, the segment of the internal carotid artery travels just above the foramen lacerum.

Recently, Bouthillier et al. proposed a classification system that describes the entire internal carotid artery, using a numerical scale according to the direction of blood flow, and identifying the segments of the internal carotid artery according to the anatomy surrounding it and the compartments through which it travels [1]. According to this classification, the internal carotid artery has seven segments: C1, cervical; C2, petrous; C3, lacerum; C4, cavernous; C5, clinoid; C6, ophthalmic; and C7, communicating. According to this classification, the third segment of the internal carotid artery is the lacerum segment. This segment starts from the internal opening of the carotid canal (the ending point of the carotid canal) and ends at the superior margin of the petrolingual ligament [1].

The size and shape of the foramen lacerum is different from case to case. This report presents six cases because of the coalescence of the foramen lacerum with its slit-like appearance. The dimensions of the foramen lacerum were evaluated based on the three-dimensional volume rendered neurovascular images that depict the micro-vascular anatomy of the foramen lacerum and based on review of the literature.

Material and Method

Any additional radiological examinations were performed and drugs were provided to the patients for this study, as necessary and appropriate. The patients in this study arrived at our neurosurgery department because of subarachnoid hemorrhage; it was decided to perform a 3D-CTA for cerebral aneurysm evaluation. The raw data of the 3D-CTA were transferred and recorded in a computational software database. Some of these raw data were used for software analysis of the three-dimensional anatomy of the carotid canal. Any additional procedures were performed on the patients, as needed.

To evaluate the presence or absence of intracranial aneurysms, the patients included in this study were evaluated with computerized tomographic angiography. When an aneurysm was detected, the optimal management, either surgical clipping or endovascular coiling, was offered to the patients and their families.

The images analyzed in this study were captured using the Aquilion ONE multidetector row computerized tomography scanner (Toshiba, Medical Systems, Tokyo, Japan). All patients were instructed to lie on the table with mouth and eyes closed. An ex-

ternal fixation device was used when necessary to stabilize the patient's head. After obtaining a frontal and lateral scanogram, a conventional unenhanced computerized tomography was performed, when necessary, depending on the clinical purpose (120 kV, 200 mAs).

Computerized tomographic angiography images were acquired following intravenous timed injection of a contrast agent (Visipaque [Iodixanol] 270 mg/100 ml, OPAKIM) using an auto-triggered mechanical injector. The injection rate was 4 ml/s to a total injection volume of 40 ml of contrast agent followed by injection of 20 ml of contrast agent at 3 ml/s. Transverse scans were acquired in the helical mode with radiation parameters 120 kV and 300 mA, matrix size 512 x 512, field of view (FOV) 28-32 cm, slice thickness 1 mm, pitch 1.0, and isotropic voxel size 0.5 mm. The acquisition time was 11-16 s.

Imaging data were stored in digital imaging and communications in medicine (DICOM) format and subsequently analyzed with OsiriX imaging software (OsiriX Foundation, Geneva, Switzerland). Three-dimensional reconstruction of the data was performed to permit viewing of the anatomical area of interest. Settings for the three-dimensional reconstruction algorithm are described below. The database window of the program was opened to find the patient's two-dimensional computerized tomographic angiography images sequence. The imaging cluster was unpacked to the front window. The 3D Volume Rendering option was selected to create a three-dimensional volume rendered image after the opening of 2D/3D Reconstruction Tools from the dashboard. Following the automatic opening of the next window, the volume rendered image graphics processing unit (GPU) engine was selected to render the image at the best resolution. If it is necessary to remove the artifact from the head fixation device, the Sculpt function can be selected for removing the artifact from the working window. A mouse button function permits rotating and viewing the images around a focal point perpendicular to the anatomic area of interest. The button for the zoom function can be also selected for magnification of the image. Then, Window-Level section was selected to select the opacity of the image for maximal reconstruction of the vascular and/or bone structures. The Measurement button was selected for the estimation of diameter, width, and length of the structures as well as the measurement of the distance between two different points.

Results

Three-dimensional volume rendered neurovascular images of the 6 patients (3 male and 3 female) showed the coalescence of the foramen lacerum. The mean age of the patients was 54.5±10.4. Three-dimensional volume rendered neurovascular images based on the computerized tomographic angiography were used to analyze the shape and dimensions of the foramen (Figure 1). The type of geometrical shape was identified as slit-like foramen located between the occipital, petrous part of the temporal and sphenoidal bone. In the three male patients, the average dimension of the coalescent foramen lacerum from anterior to posterior was estimated as 0.41±0.045 centimeters on the right side and 0.2±0.03 centimeters on the left side. In the three females, the average values were estimated as 0.36±0.04 centimeters on the right side and 0.37±0.04 centimeters on the

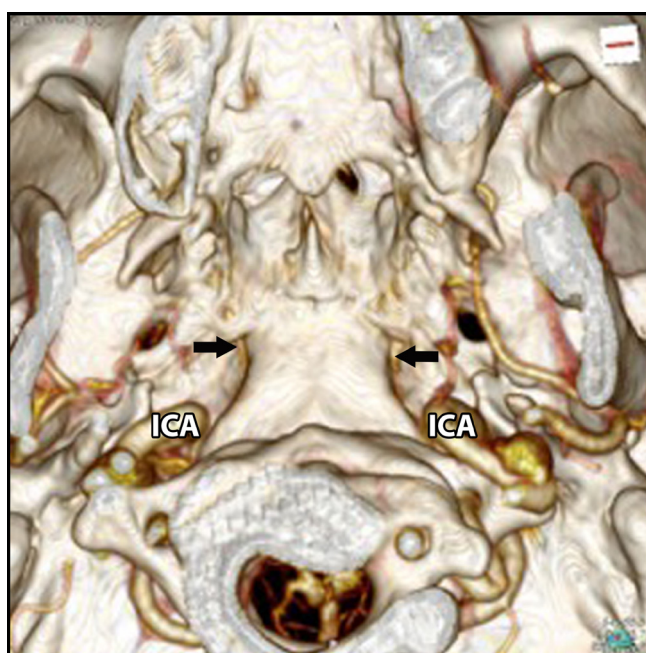


Figure 1. Three-dimensional volume rendered images of the foramen lacerum in the inferior view. (ICA: internal carotid artery, black arrows: foramen lacerum)

left side.

In the males, the average medial-lateral dimensions were estimated as 0.2 ± 0.03 centimeters on the right side and 0.23 ± 0.12 centimeters on the left side. In the females, the average medial-lateral dimensions were estimated as 0.14 ± 0.009 centimeters on the right side and 0.13 ± 0.016 centimeters on the left side. One case had unilateral coalescent foramen lacerum, while the other five cases had bilateral coalescent foramen lacerum (Table 1).

Table 1. Dimensions of the coalescent foramen lacerum, the age and sex of the cases, and intracranial vascular pathology.

No.	Sex	Age	Right		Left		Primary Pathology
			Ant-Post	Med-Lat	Ant-Post	Med-Lat	
1	M	57	0.35	0.23	0.25	0.12	No intracranial vascular pathology
2	M	45	0.46	0.15	0.39	0.18	Anterior communicating artery aneurysm
3	M	55	0.42	0.23	0.58	0.41	Anterior communicating artery aneurysm
4	F	75	0.32	0.14	0.37	0.16	Posterior Communicating artery aneurysm
5	F	52	0.43	0.14	0.32	0.12	Anterior communicating artery aneurysm
6	F	43	0.33	0.16	0.43	0.13	No intracranial vascular pathology

Discussion

The foramen lacerum is generally a triangular-shaped bony foramen located between the sphenoid, apex of the petrous temporal, and basilar part of the occipital bones. The petrous portion of the internal carotid artery and carotid sympathetic nerve plexus passes through the carotid canal to reach the foramen lacerum. The lacerum segment of the internal carotid artery passes over the foramen lacerum to reach the cavernous sinus. The anatomic location of the foramen lacerum is perpendicular. The volume rendering technique may be used in the three-dimensional evaluation of some anatomical structures such as the internal carotid artery. Volume rendering technique is a group of modalities for converting two-dimensional images to three-dimensional images [2,4]. The two-dimensional images acquired by computerized tomography and magnetic resonance imaging are used to create the volume rendered images [2,3]. Digital subtraction angiography is still the most sensitive diagnostic procedure in the evaluation of intracranial and extracranial vascular lesions such as aneurysms and arteriovenous malformations [4]. However, digital subtraction angiography is expensive, invasive, and brings some associated (1.5% to 2.0%) risk of significant morbidity and mortality [7]. Computerized tomographic angiography with its three dimensional advantage is commonly used for intracranial aneurysm detection. In the published literature, the diagnostic sensitivity of computerized tomographic angiography has been reported between 70% and 96% depending on the size and location of the pathology [5,6,8,9]. Three-dimensional viewers provide modern rendering modes such as multiplanar reconstruction, surface rendering, volume rendering, and maximum intensity projection. In the present study, we used OsiriX software in the processing of DICOM images. This software may show the basal cerebral arteries and cervical segment of the internal carotid arteries together with the bone structure of the cranial base including the carotid canal.

In this study, three-dimensional volume rendering technique was used to evaluate the coalescence of the foramen lacerum. The exit foramen of the carotid canal opens to the foramen lacerum. The inferior bony border of the carotid canal is the posterior border of the foramen lacerum. The anterior-to-posterior and medial-to-lateral dimensions of the foramen lacerum were estimated. The results of this study demonstrate that the three-dimensional volume rendering technique can show the coalescence of foramen lacerum, and may be used in the evaluation of cranial base structure including micro-vascular surgical anatomy.

Competing interests

The authors declare that they have no competing interests.

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